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Cocoa versus Tengkawang (*Shorea sp.*) Butter: A PRISMA-Based Systematic Review of Composition, Processing, Applications, and Market Opportunities

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ABSTRACT
Cocoa butter is the primary vegetable fat used in the food, cosmetic, and pharmaceutical industries because of its desirable physicochemical properties. Increasing demand and supply limitations have encouraged the exploration of sustainable alternatives, including tengkawang (*Shorea* sp.) fat. This review aimed to compare cocoa butter and tengkawang fat regarding processing technology, chemical composition, physicochemical characteristics, industrial applications, economic value, and future prospects. A Systematic Literature Review (SLR) following the PRISMA guidelines was conducted using articles published between 2017 and 2026 from major international and national scientific databases. The selected studies were analyzed through qualitative synthesis. The results showed that tengkawang fat has a fatty acid composition, triglyceride profile, melting point, and oxidative stability comparable to cocoa butter, making it a promising natural cocoa butter equivalent (CBE). Its simpler processing and broad applications in chocolate, confectionery, cosmetics, and pharmaceutical products provide additional economic and environmental advantages. As a non-timber forest product, tengkawang fat also supports sustainable forest management and local livelihoods. Further improvements in cultivation, processing technology, and quality standardization are needed to enhance its industrial competitiveness and global market potential.

INTRODUCTION

Vegetable fats are important raw materials in the food, cosmetics, and pharmaceutical industries because their physical and chemical characteristics determine product quality. Cocoa butter (*Theobroma cacao* L.) has long been the chocolate industry standard due to its distinctive melting properties, good oxidative stability, and triglyceride profile that supports the formation of a quality chocolate texture. The increasing industrial demand for cocoa butter has driven the search for alternative fat sources with similar characteristics (Loke et al., 2024).

Indonesia has significant potential in tengkawang fat, derived from several Shorea sp. species. This fat contains stearic acid, oleic acid, and palmitic acid, with physical properties similar to cocoa butter, making it potentially useful as a cocoa butter equivalent or as a natural cosmetic raw material (Mokbul & Siow, 2022). However, tengkawang fat processing is still dominated by traditional methods, resulting in variable product quality and requiring improved extraction, purification, and storage technologies.

In addition to differences in processing technology, the two types of fat also differ in chemical composition, physicochemical characteristics, and potential uses in the food and cosmetics industries. Cocoa butter has a well-established global supply chain, while the use of tengkawang fat remains limited by quality standards, raw material availability, and the underdevelopment of downstream industries. Yet, developing tengkawang fat has the potential to increase the added value of non-timber forest products while supporting the diversification of sustainable vegetable fat sources.

Most research still examines cocoa butter and tengkawang fat separately. Studies that comprehensively compare the two fats in terms of processing, chemical composition, physicochemical properties, industrial applications, economic value, and development prospects are still limited. Therefore, this review article aims to present a scientific synthesis that provides a comprehensive overview of the potential of tengkawang fat as an alternative or complement to cocoa butter in the food and cosmetics industries.

This review article aims to analyze and compare the quality of cocoa butter and tengkawang fat based on processing technology, chemical composition, physicochemical properties, industrial applications, economic value, and development prospects. The study results are expected to provide a scientific basis for the development of processing technology, product diversification, and the utilization of tengkawang fat as a value-added commodity that supports the food, cosmetics, and sustainable forest resource management industries.

RESEARCH METHODS

The Systematic Literature Review (SLR) method used in this research (Xiao & Watson, 2019), referring to the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) to compare the quality of cocoa butter (*Theobroma cacao* L.) and tengkawang (*Shorea sp.*) fat. The research stages included formulating research questions, establishing a search strategy, selecting articles based on inclusion and exclusion criteria, data extraction, assessing article quality, and synthesizing the research results.

The literature search was conducted in international and national scientific databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, PubMed, and Google Scholar. Articles published between 2017 and 2026 were searched using a combination of keywords related to cocoa butter, tengkawang fat, lipid composition, processing, food applications, cosmetic applications, economic value, and development prospects, using Boolean operators (AND and OR).

Articles were selected based on established criteria: Indonesian or English-language publications discussing cocoa butter, tengkawang fat, or both, published in reputable peer-reviewed journals. Articles with incomplete manuscripts, insufficient data, duplicates, or articles not aligned with the research objectives were excluded from the selection process. All articles were screened through the Identification, Screening, Eligibility, and Inclusion stages.

Data from articles meeting the criteria were systematically extracted, including publication information, processing methods, chemical composition, physicochemical characteristics, applications in the food and cosmetics industries, economic value, and key research findings. Article quality was assessed based on methodological clarity, data completeness, analytical validity, and relevance to the study objectives, ensuring that only articles meeting scientific standards were used in the synthesis. The analysis was conducted using qualitative systematic synthesis, comparing research results based on aspects of processing technology, chemical composition, physicochemical characteristics, industrial applications, economic value, and development prospects.

RESULTS AND DISCUSSION

The comparison between cocoa butter and tengkawang (Bornean illipe nut) butter has been extensively researched, necessitating a review of the similarities, differences, and implications of their characteristics for the quality of the final product. The first comparison concerns the processing methods of cocoa butter and tengkawang fat, as shown in Table 1.

Table 1. Comparison of Processing Methods for Cocoa and Tengkawang Butter.

Processing stages	Cocoa Butter	Tengkawang Butter
Raw material	Cocoa (*Theobroma cacao*) seeds	Tengkawang (*Shorea sp.*) seeds
Initial Treatment	Includes fermentation, drying, roasting, winnowing, and then grinding into cocoa liquor.	This process generally only involves sorting, drying, peeling, and crushing the seeds. It does

		not require fermentation or roasting.
Extraction methods	Cocoa liquor is predominantly processed using hydraulic or screw presses. In some industries, supercritical extraction is used as an alternative. Some processes add bleaching and deodorization to meet food and cosmetic standards.	Traditionally using boiling and pressing. Industries are starting to use hydraulic presses or screw presses to increase yield and quality.
Refining	Through filtration, degumming, deodorization, and removal of solid particles, high-quality cocoa butter is obtained.	Filtration and refining remove dirt, water, and impurities. Some processes add bleaching and deodorization to meet food and cosmetic standards.
Further processing	Used directly or fractionated and blended with other vegetable fats to produce cocoa butter equivalent (CBE), replacer (CBR), or substitute (CBS).	It can be used directly as CBE due to its fatty acid profile and melting point close to cocoa butter or further refined according to industrial needs.
Process Characteristics	The process is relatively lengthy because it involves fermentation, roasting, liquor formation, extraction, refining, and tempering.	The process is simpler because it doesn't involve fermentation or roasting, reducing processing time.

Based on the processing stages, cocoa butter and tengkawang fat differ, influenced by the characteristics of the raw materials and their intended use. Cocoa butter processing is more complex because it aims to produce the distinctive flavor, aroma, and physical properties of chocolate products, while tengkawang fat processing focuses more on maintaining the quality of the natural fat as a raw material for food and cosmetics (Afoakwa, 2022). Cocoa beans require fermentation, drying, and roasting to form flavour precursors and reduce bitter-causing compounds, while tengkawang beans simply undergo sorting, drying, dehulling, and crushing to maintain lipid stability and suppress free fatty acid formation (De Vuyst & Leroy, 2020).

Differences are also evident in the extraction, purification, and crystallization control stages. Both fats can be extracted using a hydraulic press or a screw press, although traditional methods are still commonly used for tengkawang fat. The refining stage in both processes aims to remove impurities and improve oxidative stability through processes such as filtration, bleaching, and deodorization (Gunstone, 2020). However, cocoa butter requires tempering to form β(V) crystals, which contribute to the gloss, texture, and stability of chocolate products. Tengkawang fat generally does not require tempering, except when used as a cocoa butter equivalent (CBE) to achieve crystallization characteristics consistent with cocoa butter (Azizian et al., 2021).

Cocoa butter processing is longer and more complex, involving flavour development through fermentation and roasting, as well as crystallization control through tempering (Afoakwa, 2022). Conversely, tengkawang fat processing is simpler, requiring less energy, time, and cost. Furthermore, tengkawang fat's triglyceride composition, which is close to that of cocoa butter, allows it to be used as a CBE with relatively minimal modification. The development of more modern extraction and purification technologies is expected to improve the quality and competitiveness of tengkawang fat as a raw material for the food, cosmetics, and oleochemical industries (Kurniawansyah et al., 2026).

The comparison of the chemical composition of cocoa and tengkawang butter is shown in Table 2.

Table 2. Comparison of Chemical Composition for Cocoa and Tengkawang Butter.

Processing stages	Cocoa Butter	Tengkawang Butter
Main fatty acids	Dominated by palmitic acid (24-27%), stearic acid (34-37%), and	Dominated by palmitic acid (16-24%), stearic acid (40-47%), and

	oleic acid (32-36%). These three fatty acids constitute more than 90% of the total fatty acids.	oleic acid (31-33%). Stearic acid content is generally higher than that of cocoa butter.
Saturated fatty acids	About 58-62% of total fatty acids. The main fraction consists of palmitic and stearic acids.	About 60-70% of total fatty acids. The predominance of stearic acid contributes to the hardness of fats.
Unsaturated fatty acids	Oleic acid dominates at around 32-36%; linoleic acid only accounts for around 2-4%.	Oleic acid dominates at around 31-33%; linoleic acid content is generally less than 3%.
Main Triglycerides	POP (1,3-dipalmitoyl-2-oleoyl-glycerol), POS (1-palmitoyl-2-oleoyl-3-stearoyl-glycerol), and SOS (1,3-distearoyl-2-oleoyl-glycerol) are the dominant triglycerides.	POS and especially SOS dominate. The higher SOS content results in crystallisation properties closer to cocoa butter.
Minor Compounds	Contains small amounts of tocopherols (α, γ, δ), phytosterols, phospholipids, and polyphenols.	Contains tocopherols and phytosterols, but the content of minor compounds is lower than in cocoa butter due to the refining process.
Iodine Number	Around 33-38 g I_2/100 g, indicating a relatively low level of unsaturation.	Around 28-38 g I_2/100 g, nearly equivalent to cocoa butter, making it suitable as a cocoa butter equivalent (CBE).
Saponification number	Around 188-198 mg KOH/g.	Around 185-200 mg KOH/g. This value is close to that of cocoa butter.
Melting point	Around 32-35°C, so it melts at body temperature.	Around 35-37°C, so it is slightly higher than cocoa butter due to the greater stearate content.
Oxidative stability	High due to its low unsaturated fatty acid content and supported by natural tocopherols.	High due to its high stearic acid content and low linoleic acid content.

Based on their chemical composition, cocoa butter and tengkawang fat (illipe butter) have very similar compositions, particularly in their fatty acid and triglyceride profiles. Both fats are dominated by palmitic acid, stearic acid, and oleic acid, accounting for more than 90% of the total fatty acids. Tengkawang fat has a higher stearic acid content (40–47%) than cocoa butter (34–37%), resulting in a harder texture and a slightly higher melting point (35–37°C compared to 32–35°C). These characteristics enhance product stability at tropical temperatures without significantly reducing its nutritional value, as stearic acid does not raise LDL cholesterol levels like other saturated fatty acids (Azizian et al., 2021).

The main similarity between the two fats lies in their triglyceride composition, particularly the POP, POS, and SOS fractions, which determine crystallization properties and melting behavior. Tengkawang fat even has a relatively higher SOS content, allowing it to function as a cocoa butter equivalent (CBE) without requiring complex chemical modification (Akanda et al., 2020). Furthermore, both fats have a low linoleic acid content, an iodine value of approximately 28–38 g I_2/100 g, and a saponification value of 185–200 mg KOH/g. These parameters indicate a low level of unsaturation, high oxidative stability, and suitability for food and cosmetic applications (Gunstone, 2020).

Both fats also contain minor compounds, such as tocopherols and phytosterols, which act as natural antioxidants and help maintain quality during storage (Zeb, 2020). Overall, the similarities in fatty acid profiles, triglyceride composition, and physicochemical properties suggest that tengkawang fat is one of the most promising natural CBEs. The main difference lies in the higher stearic acid content, which contributes to a slightly higher hardness and melting point. These characteristics are actually an advantage for developing chocolate products in tropical regions because they increase physical stability during storage and distribution (Yamada et al., 2019).

The comparison of cosmetic products derived from cocoa and tengkawang butter is shown in Table 3.

Table 3. The Comparison of Cosmetic Products Derived from Cocoa and Tengkawang Butter

Cosmetic Products	Cocoa Butter	Tengkawang Butter
Body moisturizer (body butter/body cream)	Widely used as a natural emollient because it can increase skin moisture, repair the skin barrier, and provide a soft, creamy texture.	It has similar functions as an emollient with high occlusive properties, effectively maintaining skin moisture for a long time.
Hand and body lotion:	Used as a lotion base to increase viscosity, softness, and emulsion stability.	It has been formulated into a hand and body lotion with physical characteristics that meet quality requirements for 28 days of storage.
Lipstick:	Functions as a fat base that provides a dense texture, adhesion, and an emollient effect on the lips. It can replace cocoa butter as a lipstick base.	Illipe butter-based lipsticks exhibit good homogeneity, pH, and stability and are preferred by panelists in sensory testing.
Lip balm	Used as the main ingredient in lip balms because it has a melting point close to body temperature and provides a moisturizing effect on the lips.	Used as a natural alternative to cocoa butter because it has emollient properties and creates a protective layer on the surface of the lips.
Face cream	Functions as a natural emollient and thickener that increases emulsion stability and provides a soft sensation on the skin.	Used as the oil phase in face creams because it contains triglycerides and fatty acids that support skin moisturizing functions.
Solid Soap	Increases soap hardness, produces a soft lather, and provides a moisturizing effect on the skin.	Used as a vegetable fat to increase soap hardness and reduce dryness after use.
Anti-aging products	The content of triglycerides, tocopherols, and bioactive compounds supports skin protection against oxidative stress, making it widely used in anti-aging creams.	It has potential for use in anti-aging products through its emollient effect and as a carrier for lipophilic active ingredients in cosmetic formulations.
Sensitive skin care products	Widely used in products for dry and sensitive skin due to its non-irritating properties.	It has high emollient properties, making it suitable for moisturizing cosmetic formulations for dry and sensitive skin.
Nanoparticle-based cosmetics	Cocoa butter is beginning to be used as a lipid matrix in active ingredient delivery systems (lipid carriers) in cosmetics and pharmaceuticals.	Illipe butter has been developed as a nanostructured lipid carrier (NLC) to increase the stability and effectiveness of delivering anti-inflammatory active ingredients in cosmetics.

Based on a comparison of cosmetic applications, cocoa butter and tengkawang butter primarily function as natural emollients, increasing skin moisture, improving skin barrier function, and maintaining the stability of cosmetic formulations. This similarity stems from the predominance of stearic acid, oleic acid, and palmitic acid, which result in melting points close to body temperature, good spreadability, and the ability to form an occlusive layer that reduces transepidermal water loss (TEWL) (Baki & Alexander, 2022). In moisturizers, body butters, body creams, hand and body lotions, and facial creams, both fats function as the oil phase, increasing hydration, viscosity, emulsion stability, and application comfort. The higher stearic acid content in tengkawang fat provides better occlusive power and formulation stability (Akanda et al., 2020).

In cosmetic products, cocoa butter has long been used as a key ingredient in lipsticks and lip balms because it provides a dense texture, adhesion, and a smooth feel upon application. Tengkawang fat exhibits comparable characteristics, producing homogeneity, stability, and good acceptability in lipstick formulations, and can maintain lip moisture by forming a protective layer (Poucher & Butler, 2021). Furthermore, both fats are used in solid soaps to increase product hardness while reducing post-application drying. In anti-aging products, cocoa butter has advantages due to its tocopherol and antioxidant compound content, while tengkawang fat has the potential to act as a carrier for lipophilic active ingredients, supporting formulation effectiveness (Benson et al., 2019).

Developments in cosmetic technology indicate that both fats are beginning to be utilized as lipid matrices in nanoparticle-based delivery systems, including nanostructured lipid carriers (NLCs), to enhance the stability and penetration of active ingredients (Muller et al., 2021). Overall, the similarity in triglyceride composition, emollient properties, oxidative stability, and physical characteristics makes tengkawang fat a competitive natural alternative to cocoa butter. Its utilization not only supports the development of sustainable cosmetics but also increases the added value of Indonesian non-timber forest products through the development of a locally resource-based bioeconomy (Mukherjee et al., 2022).

The comparison of food products derived from cocoa and tengkawang butter is shown in Table 4.

Table 4. The Comparison of Food Products Derived from Cocoa and Tengkawang Butter

Processing stages	Cocoa Butter	Tengkawang Butter
Chocolate bars (dark, milk, white chocolate)	This is the primary fat that determines the texture, gloss, snap, and melting properties of chocolate. It can be used directly or as a cocoa butter equivalent (CBE) because it has a triglyceride composition and crystallization properties similar to cocoa butter.	Praline and bonbon chocolates. Provides a dense structure, glossy surface, and stability during storage. Used as a partial or complete replacement for cocoa butter to maintain texture and reduce the risk of fat bloom.
White chocolate.	It is the primary fat component along with sugar and milk because it does not contain cocoa solids. Tengkawang fat-based CBE produces white chocolate with physical characteristics, particle size distribution, and sensory properties similar to cocoa butter.	Compound chocolate. Used in premium products that require the use of pure cocoa butter. Used as a fat alternative to produce products at a lower cost while still maintaining good melting characteristics.
Confectionery products (candy coating, chocolate coating):	Used as a coating because it produces a smooth, glossy, and stable surface. It is used as a coating fat because it is	Chocolate fillings (chocolate fillings and spreads): Provides a soft texture and a distinctive melt-in-the-mouth feel. It is used as a fat ingredient to

	compatible with cocoa butter and has a suitable melting point.	increase the hardness and stability of the filling without significantly reducing sensory characteristics.
Bakery (cookies, biscuits, cakes, pastries):	Used as a premium shortening that enhances the aroma, texture, and softness of the product.	It has the potential to replace cocoa butter or specialty shortenings in bakery products that require solid fats with a medium melting point.
Ice cream and frozen desserts:	Used as a fat source to improve creaminess, stability, and melting characteristics.	It has the potential to be used as a vegetable fat source because it has a melting point close to cocoa butter and high oxidative stability.
Margarine and specialty fat:	Rarely used due to its relatively high cost compared to other vegetable oils.	It has the potential to be used as a specialty fat or premium margarine blend due to its high stearic and oleic acid content.
Cocoa Butter Equivalent (CBE) for the food industry:	It serves as the standard for comparing all CBE products.	It is one of the best natural raw materials for CBE and can be used in various chocolate products without significantly altering the physical properties.

Based on food product comparisons, cocoa butter remains the gold standard in the chocolate industry due to its distinctive physical and sensory characteristics. However, tengkawang fat (illipe butter) has a triglyceride composition, melting point, and crystallization behavior very close to cocoa butter, making it potentially useful as a natural cocoa butter equivalent (CBE) (Yamada et al., 2019). The dominance of POS and SOS triglycerides provides similar melting and crystallization properties, so partial substitution of cocoa butter with tengkawang fat generally does not cause significant changes to the physical or sensory quality of chocolate products when used in the right proportions (Akanda et al., 2020).

In various chocolate products, such as dark, milk, and white chocolate, pralines, bonbons, compound chocolate, and chocolate coatings, tengkawang fat maintains a texture, gloss, and stability similar to cocoa butter. The high SOS triglyceride content results in a stable crystal structure, which helps reduce the risk of fat bloom and increases resistance to melting, especially in tropical conditions (Gunstone, 2020). Furthermore, tengkawang fat also has potential for use in chocolate fillings, spreads, bakery products, ice cream, and frozen desserts due to its ability to provide good texture, emulsion stability, and a longer shelf life due to its high oxidative stability (Mokbul & Siow, 2022).

Tengkawang butter is one of the most promising natural CBE sources due to its high compatibility with cocoa butter without the need for complex chemical modification. In addition to supporting the formulation of various food products, tengkawang fat also has the potential to be developed as a raw material for speciality fats and premium margarines. Its utilization can reduce dependence on cocoa butter, support the use of sustainable natural raw materials, and increase the added value of Indonesian non-timber forest products through the development of a local resource-based food industry (Akanda et al., 2020).

The comparison of economic value derived from cocoa and tengkawang butter is shown in Table 4.

Table 4. The Comparison of Economic Value Derived from Cocoa and Tengkawang Butter

Processing stages	Cocoa Butter	Tengkawang Butter

Market Value	It has high economic value because it is a primary raw material for the chocolate, food, cosmetics, and pharmaceutical industries, with stable global demand.	It has high economic value as a non-timber forest product (NTFP) with the potential to replace cocoa butter in the food and cosmetics industries.
Raw material availability	availability depends on global cocoa production, which is affected by climate change, pest attacks, and production fluctuations, resulting in relatively fluctuating prices.	Availability is still limited because it depends on the fruiting season of tengkawang trees, and most of it is still harvested from natural forests.
Raw material costs:	Prices are relatively higher because global industry demand continues to increase and supply is often under pressure.	It has the potential to be cheaper than cocoa butter, making it economically viable as a cocoa butter equivalent (CBE).
Added value through processing:	Added value is obtained through processing into premium chocolate, cosmetics, pharmaceuticals, and high-value food products.	Added value increases after refining into food- or cosmetic-grade illipe butter, as well as CBE, which has a higher selling price than raw beans.
Substitution opportunities:	Serve as a quality standard, preventing it from being used as a substitute for other fats.	It has high economic potential as a partial or complete substitute for cocoa butter due to similar physicochemical characteristics, thereby reducing industrial production costs.
Value for society:	Provides primary income for cocoa farmers and supports the national and global cocoa processing industry.	Becomes a source of income for communities living around forests in Kalimantan through the utilization of non-timber forest products without cutting down trees.
Export potential:	Has a well-established export market with substantial international trade, including Indonesian exports to ASEAN+6 countries.	Potential to become a high-value export commodity if quality meets international standards for the food and cosmetics industries.
Investment feasibility:	The industry has developed, so investment is more focused on increasing efficiency and product diversification.	Process simulation analysis shows that the production of illipe butter as a CBE is economically feasible, especially if supported by improvements in refining technology and industrial scale. (W
Contribution to the Regional Economy: products. (Wiley Online Library)	Contributes to foreign exchange through the export of processed cocoa products.	Potentially improves the local economy in Kalimantan through the development of the NTFP agro-industry, job creation, and increased value-added of local product

Long-Term Prospects:	Prospects remain strong, but face challenges from climate change, rising production costs, and fluctuating raw material prices.	Prospects are very good due to the increasing demand for natural raw materials, sustainability, and the industry's need for more economical cocoa butter alternatives.

Based on economic comparisons, cocoa tengkawang butter, both have high economic value but develop within different market structures. Cocoa butter has become an established global commodity as a raw material for the chocolate, food, cosmetics, and pharmaceutical industries, while tengkawang fat continues to develop as a non-timber forest product (NTFP) with significant potential as a natural cocoa butter equivalent (CBE) (Yamada et al., 2019). The similarity of physicochemical characteristics to cocoa butter and the increasing demand for sustainable plant-based raw materials make tengkawang fat increasingly attractive for market prospects (Gunstone, 2020).

Economically, cocoa butter has a strong international market, but its availability and price are significantly influenced by global cocoa production, climate change, and pest and disease outbreaks (FAO, 2024). Conversely, the supply of tengkawang fat remains limited because it depends on the tengkawang tree's fruiting season, making cultivation and agroforestry development crucial to ensure a sustainable supply (Heri et al., 2020). However, tengkawang fat production costs are relatively low, and it can provide high added value after undergoing extraction, purification, and standardization processes, making it a potentially more economical alternative in the food and cosmetics industries (Mokbul & Siow, 2022).

The main advantage of tengkawang fat lies in its ability to partially or completely replace cocoa butter without significantly reducing product quality (Akanda et al., 2020). In addition to opening investment and export opportunities, the development of the tengkawang fat industry provides economic benefits to communities surrounding forests by increasing the added value of non-timber forest products, creating jobs, and strengthening the local resource-based bioeconomy. With support from downstream processing, improved processing technology, and quality certification, tengkawang fat has the potential to become a leading Indonesian commodity, supporting economic growth and tropical forest conservation.

The comparison of the future prospects of cocoa and tengkawang butter is shown in Tabel 5..

Table 5. The Comparison of the Future Prospects from Cocoa and Tengkawang Butter

Processing stages	Cocoa Butter (Anoraga et al., 2024)	Tengkawang Butter (Darmawan et al., 2024)
Initial Treatment	Includes fermentation, drying, roasting, winnowing, and then grinding into cocoa liquor.	This process generally only involves sorting, drying, peeling, and crushing the seeds. It does not require fermentation or roasting.
Extraction methods	Cocoa liquor is predominantly processed using hydraulic or screw presses. In some industries, supercritical extraction is used as an alternative. Some processes add bleaching and deodorization to meet food and cosmetic standards.	Traditionally using boiling and pressing. Industries are starting to use hydraulic presses or screw presses to increase yield and quality.
Refining	Through filtration, degumming, deodorization, and removal of solid particles, high-quality cocoa butter is obtained.	Filtration and refining remove dirt, water, and impurities. Some processes add bleaching and deodorization to meet food and cosmetic standards.

Further processing	Used directly or fractionated and blended with other vegetable fats to produce cocoa butter equivalent (CBE), replacer (CBR), or substitute (CBS).	It can be used directly as CBE due to its fatty acid profile and melting point close to cocoa butter or further refined according to industrial needs.
Process Characteristics	The process is relatively lengthy because it involves fermentation, roasting, liquor formation, extraction, refining, and tempering.	The process is simpler because it doesn't involve fermentation or roasting, reducing processing time.

Based on its development prospects, cocoa butter is expected to remain a primary raw material for the food, cosmetics, and pharmaceutical industries because its physical and sensory characteristics have become global standards. Conversely, tengkawang fat (illipe butter) has increasingly promising prospects as a natural cocoa butter equivalent (CBE) due to its physicochemical properties, which are close to those of cocoa butter, and the increasing demand for sustainable plant-based raw materials (Yamada et al., 2019). Rising cocoa butter prices and limited cocoa supply due to climate change also strengthen the opportunity to develop tengkawang fat as a more economical alternative (FAO, 2024).

The development of both commodities is heavily influenced by technological innovation and raw material sustainability. For cocoa butter, innovation focuses on improving processing efficiency, controlling crystallization, and developing value-added products. Meanwhile, tengkawang fat still offers broader innovation opportunities, ranging from improvements in extraction, refining, and fractionation technology to the development of food, cosmetics, pharmaceuticals, and specialty fats (Gunstone, 2020). Another advantage is that the raw material source comes from non-timber forest products that can be utilized without cutting down trees, thus supporting forest conservation and a community-based bioeconomy (Heri et al., 2020).

Cocoa butter is expected to maintain its position as a global industry standard, while tengkawang fat has significant potential to develop as a strategic Indonesian commodity. Cultivation development, downstream processing, quality standardization, and industrial investment will be important factors in increasing the competitiveness of tengkawang butter in the international market. With the support of technology and sustainable management, tengkawang fat has the potential to become a leading non-timber forest product commodity that can increase economic added value while supporting tropical forest conservation (Akanda et al., 2020).

CONCLUSION

Tengkawang fat (*illipe butter*) has physicochemical characteristics that closely resemble cocoa butter, including fatty acid composition, triglyceride profile, melting point, and oxidative stability, making it a promising natural cocoa butter equivalent (CBE) for food, cosmetic, and pharmaceutical applications. It can partially or fully replace cocoa butter in chocolate, confectionery, bakery, and specialty fat products while also serving as an effective emollient and moisturizer in cosmetic formulations such as lotions, body butter, lip balm, lipstick, and facial cream. Compared with cocoa butter, its processing is simpler because it does not require fermentation, roasting, or tempering, offering potential reductions in production costs and energy use. As a non-timber forest product, tengkawang fat also provides opportunities to diversify bioresource-based industries, increase local value addition, improve forest-dependent livelihoods, and support sustainable forest management. Although its development is constrained by limited raw material supply, irregular fruiting, and the need for improved processing technology and quality standardization, advances in cultivation, extraction, refining, and supply chain development could substantially enhance its competitiveness in global markets and strengthen its role as a strategic Indonesian bioeconomy commodity.

DECLARATION

The authors state that they use AI: Grammarly, and Quillbot to check grammar and paraphrase when writing articles.

REFERENCES

Afoakwa, E. O. (2022). Chocolate Science and Technology. In *Chocolate Science and Technology: Second Edition* (3rd ed.). Wiley. https://doi.org/10.1002/9781118913758

Akanda, M. J. H., M.R, N., F.S, A., Shaarani, S., Mamat, H., Lee, J. S., Norliza, J., Mansoor, A. H., Selamat, J., Khan, F., Matanjun, P., & Islam Sarker, M. Z. (2020). Hard Fats Improve the Physicochemical and Thermal Properties of Seed Fats for Applications in Confectionery Products. *Food Reviews International*, *36*(6), 601–625. https://doi.org/10.1080/87559129.2019.1657443

Anoraga, S. B., Shamsudin, R., Hamzah, M. H., Sharif, S., & Saputro, A. D. (2024). Cocoa by-products: A comprehensive review on potential uses, waste management, and emerging green technologies for cocoa pod husk utilization. *Heliyon*, *10*(16), e35537. https://doi.org/10.1016/j.heliyon.2024.e35537

Azizian, H., Dugan, M. E. R., & Kramer, J. K. G. (2021). Clarifications of the Carbonyl and Water Absorptions in Fourier Transform Near Infrared Spectra from Extra Virgin Olive Oil. *European Journal of Lipid Science and Technology*, *123*(5). https://doi.org/10.1002/ejlt.202000288

Baki, G., & Alexander, K. S. (2022). *Introduction to Cosmetic Formulation and Technology*.

Benson, H. A. E., Grice, J. E., Mohammed, Y., Namjoshi, S., & Roberts, M. S. (2019). Topical and Transdermal Drug Delivery: From Simple Potions to Smart Technologies. *Current Drug Delivery*, *16*(5), 444–460. https://doi.org/10.2174/1567201816666190201143457

Darmawan, M. A., Abd-Aziz, S., & Gozan, M. (2024). Cocoa Butter Substitute from Tengkawang (Shorea stenoptera). In *Chemical Substitutes from Agricultural and Industrial By-Products* (pp. 235–254). Wiley. https://doi.org/10.1002/9783527841141.ch12

De Vuyst, L., & Leroy, F. (2020). Functional role of yeasts, lactic acid bacteria and acetic acid bacteria in cocoa fermentation processes. *FEMS Microbiology Reviews*, *44*(4), 432–453. https://doi.org/10.1093/femsre/fuaa014

FAO. (2024). The State of Agricultural Commodity Markets 2024. In *The State of Agricultural Commodity Markets 2024*. https://doi.org/10.4060/cd2144en

Gunstone, F. D. (2020). Production and Trade of Vegetable Oils. In *Vegetable Oils in Food Technology: Composition, Properties and Uses, Third Edition*. https://doi.org/10.1002/9781444339925.ch1

Heri, V., Bakara, D. ., Hermanto, Mulyana, A., Moeliono, M., & Yuliani, E. L. (2020). Illipe nut as the glue for integrated watershed management: Experiences from the Labian-Leboyan watershed. *Illipe Nut as the glue' for Integrated Watershed Management: Experiences from the Labian-Leboyan Watershed*, *295*. https://doi.org/10.17528/cifor/007718

Kurniawansyah, I. S., Chaerunisaa, A. Y., & Akmalia, N. N. N. (2026). Bioactive-fat engineered nanostructured lipid carriers from Illipe butter: optimized design and enhanced in vitro anti-inflammatory performance. *Scientific Reports*, *16*(1), 1–14. https://doi.org/10.1038/s41598-026-43880-3

Loke, Y. H., Phang, H. C., Mohamad, N., Kee, P. E., Chew, Y. L., Lee, S. K., Goh, C. F., Yeo, C. I., & Liew, K. Bin. (2024). Cocoa Butter: Evolution from Natural Food Ingredient to Pharmaceutical Excipient and Drug Delivery System. *Planta Medica*, *90*(11), 824–833. https://doi.org/10.1055/a-2359-8097

Mokbul, M., & Siow, L. F. (2022). Cocoa Butter Alternatives for Food Applications. *Recent Advances in Edible Fats and Oils Technology: Processing, Health Implications, Economic and Environmental Impact*, 307–331. https://doi.org/10.1007/978-981-16-5113-7_11

Mukherjee, S., Date, A., Patravale, V., Korting, H. C., Roeder, A., & Weindl, G. (2022). Retinoids in the treatment of skin aging: an overview of clinical efficacy and safety. *Clinical Interventions in Aging*, *1*(4), 327–348. https://doi.org/10.2147/ciia.2006.1.4.327

Muller, R. H., Shegokar, R., & Keck, C. M. (2021). 20 Years of Lipid Nanoparticles (SLN & NLC): Present State of Development & Industrial Applications. *Current Drug Discovery Technologies*, *8*(3), 207–227. https://doi.org/10.2174/157016311796799062

Poucher, W. A., & Butler, H. (2021). *Poucher's Perfumes, Cosmetics and Soaps*.

Xiao, Y., & Watson, M. (2019). Guidance on Conducting a Systematic Literature Review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Yamada, K., Ibuki, M., & McBreayer, T. (2019). Cocoa butter, cocoa butter equivalents, and cocoa butter substitutes. In *Healthfull Lipids*. https://doi.org/10.1201/9781420039184.ch12

Zeb, A. (2020). Concept, mechanism, and applications of phenolic antioxidants in foods. *Journal of Food Biochemistry*, *44*(9), 1–22. https://doi.org/10.1111/jfbc.13394